627 Rec'd TO 20 NOV 2000

FORM PTO-1390 (REV. 5-93)

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER
11150/29

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
09/700833

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP 99/03378	17 May 1999	20 May 1998

TITLE OF INVENTION
FUEL CELL SYSTEM AND METHOD FOR GENERATING ELECTRICAL ENERGY USING A FUEL CELL SYSTEM

APPLICANT(S) FOR DO/EO/US
DUEBEL, OLAF; KOENIG, AXEL; EKDYNGE, PER; ALIN, PETER; REINKINGH, JESSICA; MALLANT, RONALD

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
    ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:search report, IPER - English translation

EXPRESS NO. EL594608034US

U.S. APPLICATION NO. If known, see 37 C.F.R.1.5	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/700833	PCT/EP 99/03378	11150/29

17. ☐ The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO $860.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) ... $690.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1000.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	24 - 20 =	4	X $18.00	$ 72	
Independent Claims	2 - 3 =	0	X $80.00	$	
Multiple dependent claim(s) (if applicable)			+ $270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$932	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).			+	$	
TOTAL NATIONAL FEE =				$932	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property			+	$	
TOTAL FEES ENCLOSED =				$932	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of $932.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Kenyon & Kenyon
One Broadway
New York, New York 10004

SIGNATURE

RICHARD L. MAYER
NAME

22,490
REGISTRATION NUMBER

15/20/00
DATE

328519-1

[11150/29]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Olaf DUEBEL et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	FUEL CELL SYSTEM AND METHOD FOR GENERATING ELECTRICAL ENERGY USING A FUEL CELL SYSTEM
Examiner	:	To Be Assigned
Art Unit	:	To Be Assigned

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

S I R:

Kindly amend the above-captioned application before examination, as set forth below.

IN THE SPECIFICATION:

Please amend the specification as follows:

On page 1, before line 1, insert --FIELD OF THE INVENTION--.

On page 1, line 1, change "according" to --, particularly--.

On page 1, line 2, delete "to the definition of the species in Claim 1, especially".

On page 1, line 4, change "especially" to --such as, for example,--.

On page 1, line 6, change "; an" to --. An--.

On page 1, line 7, change "being" to --is--.

On page 1, line 8, insert --the-- before "fuel-cell".

On page 1, line 9, change "processes" to --a method--.

On page 1, line 10, change "especially" to --particularly--.

On page 1, line 11, change "; hydrogen being" to --. Hydrogen is--.

On page 1, line 13, change "; and carbon" to --. Carbon-- and change "being" to --is--.

On page 1, line 14, delete ",".

On page 1, line 15, change ", in accordance with the first part" to --.--.

On page 1, line 16, delete "of Claim 10."

On page 1, before line 18, insert --BACKGROUND INFORMATION--.

On page 1, line 19, change "known from EP" to --described, for example, in European Published Patent Application No.--.

On page 1, line 22, change "in such a manner," to --so--.

On page 1, line 26, change "In a further development of this system," to --International Published Patent Application No.--.

On page 1, line 28, change ", in such a manner," to --so--.

On page 2, line 1, change the first instance of "DE" to --German Published Patent Application Nos.--, delete the first instance of "C2", delete the second instance of "DE" and change the second instance of "C2" to --each--.

On page 2, line 3, change "This" to --The--.

On page 2, line 7, delete "," and insert --is-- before "rather".

On page 2, line 11, change "known from DE" to --described in German Published Patent Application No.-- and delete "A1".

On page 2, line 12, change "in such a manner," to --so--.

On page 2, line 16, change "20/21" to --20 to 21--.

On page 2, line 18, delete "even".

On page 2, line 19, change "case" to --arrangement--.

On page 2, line 20, change "brought" to --converted--.

On page 2, line 24, insert --and-- after "monoxide,".

On page 2, line 25, change "being" to --is--.

On page 2, line 32, change "lead from" to --supplied--.

On page 2, line 33, delete "there".

On page 2, line 35, change "known from" to --described in--.

On page 2, line 36, insert --appearing-- before "in".

On page 3, line 1, change "through" to --to--.

On page 3, line 2, change "case" to --arrangement--.

On page 3, line 7, change "This" to --The-- and insert --,-- after "cell".

On page 3, line 11, insert --located-- after "which is".

On page 3, line 12, delete ",".

On page 3, line 15, change "not enough" to --an insufficient quantity of--.

On page 3, line 20, change "a represented" to --one--.

On page 3, line 21, delete "specific".

On page 3, line 25, change "DE" to --German Published Patent Application No.-- and delete "C1".

On page 3, line 30, change "on the part of" to --by--.

On page 3, line 36, change "known from EP" to --described in European Published Patent Application No.--, delete "B1" and change "case" to --arrangement--.

On page 4, line 3, change "; the" to --. The--.

On page 4, line 4, change "being" to --are--.

On page 4, line 11, change "known from" to --described in International Published Patent Application No.--.

On page 4, line 12, change "This" to --The--.

On page 4, before line 16, insert --SUMMARY--.

On page 4, line 16, change "further" to --providing--.

On page 4, line 17, delete "developing" and delete "of the type mentioned above, in".

On page 4, line 18, delete "such a manner,", delete "it" and delete "," after "economically".

On page 4, line 20, change "especially" to --particularly--.

On page 4, line 24, change "object" to --above and other beneficial objects--, change "is" to --are-- and insert --providing-- after "by".

On page 4, line 25, change "of the type mentioned above, having the features" to --and method as described and claimed herein.--.

On page 4, delete lines 26 - 29.

On page 4, line 31, change "To that end, the" to --The--.

On page 4, line 36, insert --arrangement-- after "This".

On page 5, line 4, delete "," and insert --by-- before "using".

On page 5, line 5, delete "also".

On page 5, line 7, delete "as well".

On page 5, line 13, change ". This" to --, thereby-- and change "reduces" to --reducing--.

On page 5, line 14, change ", as well as" to --and--.

On page 5, line 17, change "a preferred" to --one-- and change "has" to --includes--.

On page 5, line 18, delete the first instance of ",".

On page 5, line 19, change "especially" to --such as, for example,--.

On page 5, line 21, change "can" to --may-- and change "carry" to --transport--.

On page 5, line 22, delete "along".

On page 5, line 23, change "especially" to --such as, for example,--.

On page 5, line 26, change "; the" to --. The-- and change "removing" to --removes--.

On page 5, line 27, delete "," and change "feeding" to --supplies--.

On page 5, line 31, delete "advantageous" and insert --of the present invention-- after "embodiment".

On page 5, line 37, delete ",".

On page 6, line 1, delete ",".

On page 6, line 4, change "can" to --may--.

On page 6, line 8, change "can" to --may--.

On page 6, line 9, delete ",".

On page 6, line 10, change "particularly" to --such as, for example,--.

On page 6, line 20, change "; and" to --.--.

On page 6, line 21, change "because" to --Because--.

On page 6, line 23, delete ",".

On page 6, line 27, change "is advantageously" to --may include--.

On page 6, line 28, change "especially" to --such as, for example,--.

On page 6, line 30, change "a process of the type mentioned above," to --the method according to--.

On page 6, line 31, insert --,-- after "invention", delete "provides for" and change "being" to --is--.

On page 7, line 2, delete "," and insert --by-- after "or"

On page 7, line 4, insert --the-- before "oxygen".

On page 7, line 6, delete "as well,".

On page 7, line 11, change "." to --, thereby--.

On page 7, line 12, delete "This", change "reduces" to --reducing-- and delete ",".

On page 7, line 16, change "is" to --may be--.

On page 7, line 19, change "can" to --may-- and delete ",".

On page 7, line 23, change "can" to --may-- and change "carry" to --transport--.

On page 7, line 24, delete "along" and delete ",".

On page 7, line 27, delete ",".

On page 7, line 34, change "can" to --may--.

On page 8, line 1, change "especially" to --such as, for example,--.

On page 8, line 2, change "is advantageously" to --may be--.

On page 8, delete lines 4 - 9 and insert the following therefor:
--BRIEF DESCRIPTION OF THE DRAWING
Figure 1 is a schematic block diagram of an embodiment of a fuel-cell system according to the present invention.

DETAILED DESCRIPTION--.

On page 8, line 11, change "this" to --the-- and insert --illustrated schematically in Figure 1-- after "system".

On page 8, line 16, change "e.g." to --such as, for example,--.

On page 8, line 22, change "This" to --The--.

On page 8, line 23, change "feeding" to --supplying--.

On page 8, line 24, change "To this end, crude" to --Crude--.

On page 8, line 25, change "where" to --in which--.

On page 8, line 33, change "fed" to --supplied--.

On page 9, line 1, change "it" to --cleaned gas 38-- and change "e.g." to --for example,--.

On page 9, line 2, delete ",".

On page 9, line 8, change "the figure" to --Figure 1--.

On page 9, line 9, change "known" to --conventional-- and delete ",".

On page 9, line 13, change "This" to --The-- and delete "," after "14".

On page 9, line 16, change “e.g. ca.” to --for example, approximately-- and delete “;”.

On page 9, line 17, change “e.g.” to --for example,-- and insert --,-- after “i.e.”

On page 9, line 19, change “fed” to --supplied--.

On page 9, line 22, delete “, which”.

On page 9, line 23, change “In” to --Disposed in--.

On page 9, line 26, insert --thus-- after “is” and delete “in”.

On page 9, line 27, delete “this manner,”.

On page 9, line 28, change “carried along” to --transported--.

On page 9, line 31, insert --in Figure 1-- after “line”.

On page 10, line 6, change “passed on” to --transferred--.

On page 10, line 10, change “can” to --may-- and change “fed” to --supplied--.

On page 10, line 12, change “can” to --may-- and delete “,”.

On page 10, line 14, change “e.g.” to --for example,--.

On page 10, line 19, delete “,”.

On page 10, line 20, delete “,” after “60”.

On page 10, line 23, change “case” to --arrangement--.

On page 10, line 25, change ";" to --.--.

On page 10, line 26, change "the" to --The-- and change "being" to --is--.

On page 10, line 27, change "By this means" to --Thus--.

On page 10, line 28, delete ",".

On page 10, line 31, delete "specific".

On page 10, line 36, delete ";".

On page 12, line 1, change "Claims" to --WHAT IS CLAIMED IS:--.

IN THE ABSTRACT

Please insert the Abstract annexed hereto.

IN THE CLAIMS:

Please cancel claims 1 - 16 in the underlying PCT application.

Please add the following new claims:

--17. (New) A fuel-cell system, comprising:

a reformer unit configured to produce hydrogen from a raw material;

a fuel-cell unit disposed downstream of the reformer unit and operable in accordance with the hydrogen produced by the reformer unit;

an oxidation device configured to convert carbon monoxide into carbon dioxide and disposed between the reformer unit and the fuel-cell unit; and

a water-injection device disposed at the oxidation device and configured to inject water into the oxidation device.

18. (New) The fuel-cell system according to claim 17, wherein the fuel-cell system includes a drive system of a motor vehicle.

19. (New) The fuel-cell system according to claim 17, wherein the raw material includes a liquid raw material.

20. (New) The fuel-cell system according to claim 17, wherein the reformer unit includes a mixer configured to mix the raw material and an oxygen-containing substance.

21. (New) The fuel-cell system according to claim 20, wherein the oxygen-containing substance includes at least one of water and air.

22. (New) The fuel-cell system according to claim 17, further comprising a two-stage compressor configured to supply compressed air to at least one of a process gas between the oxidation device and the fuel-cell unit and a cathode of the fuel-cell unit.

23. (New) The fuel-cell system according to claim 17, further comprising a water separation device disposed in at least one of an exhaust-gas stream from a cathode of the fuel-cell unit, an exhaust-gas stream from an anode of the fuel-cell unit and a cleaned-gas stream from the oxidation unit, the water separating device being configured to separate the water contained in the corresponding gas and to supply the water to a water-storage device disposed upstream from the reformer unit.

24. (New) The fuel-cell system according to claim 23, wherein the water separation device includes a condenser.

25. (New) The fuel-cell system according to claim 23, further comprising a water circulation loop configured to cool at least one of the water separation device, the fuel-cell unit, air supplied to a cathode of the fuel-cell unit and air supplied to the reformer unit.

26. (New) The fuel-cell system according to claim 17, further comprising a catalytic burner configured to combust exhaust gas from an anode of the fuel-cell unit and to direct corresponding waste heat through a heat exchanger to the reformer unit.

27. (New) The fuel-cell system according to claim 26, wherein the catalytic burner is connected to a supply tank supplying the raw material.

28. (New) The fuel-cell system according to claim 17, further comprising:

an expander disposed in an exhaust-gas stream of a cathode of the fuel-cell unit; and

a compressor disposed in a supply-air stream of the fuel-cell unit;

wherein the expander and the compressor are arranged on a common shaft.

29. (New) The fuel-cell unit according to claim 28, wherein the compressor includes a two-stage compressor.

30. (New) The fuel-cell unit according to claim 17, wherein the raw material includes a hydrogen-containing substance.

31. (New) The fuel-cell unit according to claim 30, wherein the hydrogen-containing substance includes at least one of methanol and gasoline.

32. (New) A method for generating electrical energy using a fuel-cell system, comprising the steps of:

producing hydrogen from a raw material in a reforming process, a fuel-cell unit of the fuel-cell system being operable in accordance with the produced hydrogen;

oxidizing carbon monoxide into carbon dioxide after the reforming process and upstream of the fuel-cell unit; and

injecting water during the oxidizing step.

33. (New) The method according to claim 32, wherein the fuel-cell system includes a drive system of a motor vehicle.

34. (New) The method according to claim 32, wherein the water is injected as one of a vapor and an aerosol.

35. (New) The method according to claim 32, further comprising the step of supplying compressed air to at least one of a process gas between a carbon monoxide oxidizing unit and the fuel-cell unit and a cathode of the fuel-cell unit.

36. (New) The method according to claim 32, further comprising the steps of:

separating water from at least one of a cathode-exhaust stream of the fuel-cell unit and an anode-exhaust stream of the fuel-cell unit; and

supplying the separated water to the reforming process.

37. (New) The method according to claim 32, further comprising the steps of:

burning an exhaust gas from an anode of the fuel-cell unit; and

supplying waste heat generated by the burning step to the reforming process.

38. (New) The method according to claim 32, further comprising the steps of:

burning the raw material; and

supplying heat energy generated by the raw material burning step to the reforming process.

39. (New) The method according to claim 32, wherein the raw material includes a hydrogen-containing substance.

40. (New) The method according to claim 39, wherein the hydrogen-containing substance includes at least one of methanol and gasoline.

REMARKS

This Preliminary Amendment cancels, without prejudice, claims 1 - 16 in the underlying PCT Application No. PCT/EP99/03378 and adds new claims 17 - 40. The new claims, inter alia, conform the claims to U.S. Patent and Trademark Office rules and do not add any new matter to the application.

The above amendments to the specification and the abstract conform the same to U.S. Patent and Trademark Office rules and do not introduce any new matter into the application.

The underlying PCT Application No. PCT/EP99/03378 includes an International Search Report, dated October 4, 1999, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

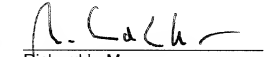
The underlying PCT Application No. PCT/EP99/03378 also includes an International Preliminary Examination Report dated April 26, 2000, a copy of which is included, including a translation.

It is respectfully submitted that the subject matter of the present application is new, non-obvious and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully submitted,

KENYON & KENYON

Dated: 11/20/06

By: 

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ABSTRACT

A fuel-cell system, particularly a fuel-cell system for a drive system of a motor vehicle, includes an autothermic reformer unit configured to generate hydrogen from a raw material. The hydrogen is used to operate a fuel-cell unit disposed downstream of the reformer unit. An oxidation device configured to convert carbon monoxide into carbon dioxide is disposed between the reformer unit and the fuel cell unit. A water injection device is disposed in the oxidation device and is configured to inject water into the oxidation device.

FUEL CELL SYSTEM AND METHOD FOR GENERATING ELECTRICAL ENERGY USING A FUEL CELL SYSTEM

The present invention relates to a fuel-cell system according to the definition of the species in Claim 1, especially a drive system of a motor vehicle, having a reformer unit for producing hydrogen from a raw material, especially a liquid raw material, while feeding in air, in order to operate a downstream fuel-cell unit; an oxidation device for converting carbon monoxide into carbon dioxide being located between the reformer unit and fuel-cell unit. In addition, the present invention relates to processes for generating electrical energy, using a fuel-cell system, especially for a drive system of a motor vehicle; hydrogen being produced from a raw material, in a reforming process, as air is fed in, in order to operate a fuel-cell unit; and carbon monoxide being oxidized to carbon dioxide after the reforming process, and in front of the fuel-cell unit, in accordance with the first part of Claim 10.

A catalytic hydrogen generator is known from EP 0 217 532, which produces hydrogen from a methanol-air mixture in an autothermal reformer unit. Located in the reformer unit is a thermocouple, which controls the supply of air to the methanol-air mixture in such a manner, that the air supply is reduced as the temperature increases at the location of the thermocouple in the reformer.

In a further development of this system, WO 96/00186 describes a hydrogen generator, the catalyst being positioned around an inlet pipe for the methanol-air mixture, in such a manner, that the methanol-air mixture flows radially through the catalyst.

DE 43 45 319 C2 and DE 43 29 323 C2 describe a fuel-cell current-generating system, in which hydrogen is produced from a methanol-water mixture in a reformer unit. This hydrogen is supplied to a downstream fuel cell for generating electrical energy. To generate a sufficient amount of heat for the reaction in the reformer, a portion of the methanol is not added to the methanol-water mixture, but rather combusted in an additional burner.

An electric vehicle having a driving battery made of fuel cells is known from DE 196 29 084 A1, the fuel cells being arranged in such a manner, that they are cooled by the wind from driving.

In the article "Heureka?" in DE-Z Autotechnik No. 5/1997, on pages 20/21, a motor vehicle having a fuel-cell drive is described, where the hydrogen necessary for operating the fuel cells in the vehicle is even obtained from gasoline. In this case, the gasoline is converted into hydrogen in a multi-step process. Prior to conversion, the gasoline is brought into the gaseous state by heating it in an evaporator. Hydrogen and carbon monoxide are formed in a partial-combustion reactor, under oxygen-deficient conditions. Copper-oxide and zinc-oxide catalysts are provided for oxidizing the carbon monoxide, steam being used to supply oxygen for the reaction. In a further step, a final carbon monoxide fraction of approximately 1% is subsequently burned in a conventional platinum oxidation catalyst. The mixture of hydrogen, carbon monoxide, and carbon dioxide obtained in this manner still contains 10 ppm carbon monoxide, which is not harmful to a downstream fuel cell. After being cooled down to approximately 80 degrees Celsius in a heat exchanger, the gas is lead from there into the fuel cell.

A similar fuel-cell system for motor vehicles is known from the article "Alternative Fuel" in the Japanese periodical, Asia-Pacific Automotive Report, 1/20/98, Vol. 272, page 34

through 39, where a methanol reformer unit is provided to produce hydrogen for a fuel cell. In this case, water produced in the electrochemical reaction of hydrogen and oxygen is reused for the reforming process. For the reforming process, deionized water and methanol are mixed, evaporated, and converted into hydrogen and carbon dioxide at a temperature of 250 degrees Celsius. This hydrogen is supplied to a fuel cell which, in a catalytic process, converts the hydrogen, together with atmospheric oxygen, into electrical energy and water. The heat energy necessary for the evaporation and for the reforming process is produced in a catalytic burner, which is downstream from the fuel cell, and is run by residual gas from the fuel cell. This gas contains hydrogen, since the fuel-cell system only utilizes approximately 75% of the supplied hydrogen. If not enough residual hydrogen is available for the catalytic burner, methanol from the fuel tank is used to generate heat for the reformer. Before introducing the gas produced in the reformer, of which a portion is hydrogen, this gas is purified by a catalytic reaction, in which carbon monoxide is converted into carbon dioxide. In a represented specific embodiment of a fuel-cell system for a motor vehicle, the methanol reformer includes an evaporator, a reformer, and an oxidation unit for carbon monoxide.

DE 43 22 765 C1 describes a method and a device for dynamically controlling the power output for a vehicle having a fuel cell, which supplies electrical energy to an electrical drive unit. Starting from a power requirement corresponding to the position of an accelerator pedal, a mass flowrate of air is calculated, which is needed on the part of the fuel cell to provide a corresponding, desired power output. The speed of a compressor positioned in an intake line of the fuel cell is controlled as a function of the required air flow rate.

A method and a device for supplying air to a fuel-cell system is known from EP 0 629 013 B1. In this case, process air is compressed by a compressor, before it enters a corresponding

fuel cell. After process air flows through the fuel cell, the removed exhaust air is expanded over a turbine, in order to recover energy; the turbine, the compressor, and an additional driving motor being arranged on a common shaft. The compressor is designed to have a variable speed, and is arranged, along with an expander in the form of a turbine, on a common shaft, in order to expand the exhaust air. The air flow rate for the fuel cell is controlled by using an expander having a variable absorption capacity.

A screw-type compressor for a refrigerator is known from WO 97/16648. This screw-type compressor includes two pump chambers, an outlet of a first pump chamber being connected to a secondary inlet of a second pump chamber.

The present invention is based on the object of further developing a fuel-cell system of the type mentioned above, in such a manner, that it can be used more economically, and in an environmentally friendlier manner, to generate electrical energy, especially for a drive system of a motor vehicle, while operating at high efficiency and occupying a small space.

The object of the present invention is achieved by a fuel-cell system of the type mentioned above, having the features indicated in Claim 1, and by a process of the type mentioned above, having the features indicated in Claim 10. Advantageous refinements of the present invention are specified in the dependent claims.

To that end, the present invention provides for a fuel-cell system having a water-injection device at the oxidation device, the water-injection device injecting water into the oxidation device.

This has the advantage that, simultaneously to removing carbon monoxide from a process gas, which is from the reformer unit

and has a high concentration of hydrogen for the fuel-cell unit, the process gas is sufficiently cooled or precooled, so that it can be directed to the fuel-cell unit without an expensive cooling device, or using a correspondingly less expensive cooling device. In addition, the injected water also supplies oxygen necessary to oxidize carbon monoxide, this oxidation reaction simultaneously releasing hydrogen as well, so that the amount of oxygen having to be separately supplied to the oxidation device can be reduced, and at the same time, the concentration of hydrogen in the process gas can be increased. At the same power output, the additional hydrogen enrichment in the oxidation device allows the fuel-cell system to be dimensioned smaller. This correspondingly reduces the required space, as well as the cost of equipment for the fuel-cell system.

In a preferred embodiment, the reformer unit has a mixer for the raw material, and an oxygen-containing substance, especially water and/or air.

A closed water cycle can be attained without having to carry along large amounts of water for the reforming process, in that a water-separation device, especially a condenser, is provided in an exhaust-gas stream from a cathode of the fuel-cell unit, and/or in an exhaust-gas stream from an anode of the fuel-cell unit; the condenser removing the water contained in the corresponding exhaust gas, and feeding it to a water storage device connected upstream from the autothermal reformer unit.

An advantageous embodiment provides a separate water cycle, which cools the water-separation devices, the fuel-cell unit, the air supplied to a cathode of the fuel-cell unit, and/or the air supplied to the reformer unit. To generate the appropriate heat energy necessary for the reaction in the reformer unit, a catalytic burner is provided, which combusts exhaust gas from an anode of the fuel-cell unit, and directs

the corresponding waste heat through a heat exchanger, to the reformer unit.

Alternatively, heat can be generated for the reformer unit by connecting the catalytic burner to a storage tank for the raw material.

Energy can be recovered by providing an expander in a cathode-exhaust stream of the fuel-cell unit, and by providing a compressor, particularly a two-stage compressor, in a supply-air stream of the fuel-cell unit, the expander and compressor being arranged on a common shaft.

Such a two-stage compressor further increases the environmental compatibility and the efficiency of the fuel-cell system, in that two tappable pressure stages provide the rest of the system with different levels of air pressure. The cathode of the fuel-cell unit is subjected to a relatively low pressure by a first stage, while a second stage initially feeds air at a higher pressure to the reformer unit; and because of its higher relative pressure level, the second stage compensates for the pressure losses occurring along the longer path, to the extent that approximately the same pressure is applied to the anode and cathode sides of the fuel-cell unit.

The raw material is advantageously a substance containing hydrogen, especially methanol or gasoline.

In a process of the type mentioned above, the present invention provides for water being injected during the oxidation of carbon monoxide to carbon dioxide.

This has the advantage that, simultaneously to removing carbon monoxide from a process gas, which is from the reforming process and has a high concentration of hydrogen for the fuel-cell unit, the process gas is sufficiently cooled or

precooled, so that it can be directed to the fuel-cell unit without an expensive cooling device, or using a correspondingly less expensive cooling device. In addition, the injected water also supplies oxygen necessary to oxidize carbon monoxide, this oxidation reaction simultaneously releasing hydrogen as well, so that the amount of oxygen having to be supplied separately to the oxidation device can be reduced, and at the same time, the concentration of hydrogen in the process gas is increased. At the same power output, the additional hydrogen enrichment in the oxidation device allows the fuel-cell system to be dimensioned smaller. This correspondingly reduces the required space, as well as the cost of equipment for the fuel-cell system.

In order for the supply water to achieve a high efficiency, it is injected in the form of a vapor or aerosol.

An additional increase in the efficiency of the fuel-cell unit can be attained by supplying compressed air to a process gas, between the carbon monoxide oxidation and the fuel-cell unit and/or to a cathode of the fuel-cell unit.

A closed water cycle can be attained without having to carry along large amounts of water for the reforming process, by removing water from a cathode exhaust stream of the fuel-cell unit and/or from an anode exhaust stream of the fuel-cell unit, and supplying it to the reforming process.

To generate the appropriate heat energy necessary for the reaction of the reforming process, an exhaust gas from an anode of the fuel-cell unit is burned, and the corresponding waste heat is supplied to the reforming process.

Alternatively, heat can be generated for the reformer unit by burning a raw material and supplying the corresponding heat energy to the reforming process.

A hydrogen-containing substance, especially methanol or gasoline, is advantageously used as a raw material.

Additional features, advantages, and advantageous refinements of the present invention proceed from the dependent claims, as well as from the following description of the present invention, in light of the included drawing. This shows a block diagram of a preferred embodiment of a fuel-cell system according to the present invention.

In this fuel-cell system, hydrogen for a fuel-cell unit 10 having an anode 12, a cathode 14, and a cooling element 16 is produced by an autothermal reformer unit 18, which includes a mixer 20, a heat exchanger 22, an evaporator 24, and a catalytic reformer 26. To produce hydrogen, a raw material, e.g. methanol from a methanol tank 28, and water from a water tank 30 are supplied to mixer 20. The mixture of methanol and water is evaporated in evaporator 24, and a process gas in the form of a crude gas 32, which has a high fraction of hydrogen, is generated in a catalytic reaction in catalytic reformer 26.

This crude gas contains, inter alia, carbon monoxide (CO), which must be removed before feeding it into fuel-cell unit 10. To this end, crude gas 32 is directed into an oxidation unit 34, where carbon monoxide is oxidized to carbon dioxide (CO_2) in the presence of air supplied by line 36, so that a CO concentration of less than 20 ppm results. At the same time, water from water tank 30 is supplied via a line 44, the supplied water being injected into oxidation unit 34 by an injection device 46. This simultaneously cools the process gas in oxidation unit 34. In an anode-gas condenser 40, the cleaned gas 38 produced and cooled in this manner has water removed from it, which is fed back to water tank 30 via line 42. Cleaned gas 38 having a high concentration of hydrogen is then directed into anode 12 of fuel-cell unit 10. For example, cleaned gas 38 contains 50% H_2, 25% N_2, and 25% CO_2 at a temperature of approximately 180 to 200 degrees Celsius.

Before being directed into anode 12, it is cooled down, e.g. to approximately 85 degrees Celsius, in anode-gas condenser 40.

On cathode side 14, compressed air from a two-stage, screw-type compressor 50 is supplied via line 48 to fuel-cell unit 10. All of the air lines are indicated by dotted lines in the figure. Thus, the fuel-cell unit generates electrical energy in a known manner, by the reaction

$$H_2 + \tfrac{1}{2} O_2 \rightarrow H_2O + \text{el. energy.}$$

This electrical energy can be tapped off at electrodes 12, 14, and supplied to an electric motor 52. Two-stage, screw-type compressor 50 includes a first stage 54 having a pressure of, e.g. ca. 3 bar for cathode 14; and a second stage 56 having a pressure of, e.g. 3.7 bar for the fuel gas, i.e. dehydrated, cleaned gas 38, to be supplied to anode 12. Using another tap on screw-type compressor 50, compressed air is fed via line 58 to cleaned gas 38, downstream from anode-gas condenser 40.

A water separator 62, which separates water from anode gas 60 and supplies it via line 64 to water tank 30. In cathode exhaust stream 66 is a condenser 68, which removes water from cathode gas 66 and supplies it via line 70 to water tank 30. A closed water circulation loop for the process gas is formed in this manner, so that large amounts of water do not have to be carried along for the production of hydrogen in reformer unit 18.

A separate water circulation loop 72 indicated by a wavy line is provided to cool the air supplied to mixer 20, to cool anode gas condenser 40, water separator 62, and condenser 68, and to cool the air 48 supplied to cathode 14. This separate water circulation loop 72 includes a cooling-water tank 74, a deionized water tank 76, and corresponding heat exchangers 78

and 80 at cathode 14 air supply 48 and mixer 20 air supply, respectively.

Anode exhaust stream 60 flows into catalytic burner 82, in which anode gas 60 is further combusted to form heat energy. This heat energy is passed on by heat exchanger 22 to evaporator 24 and catalytic reformer 26, where it sustains the catalytic reaction for producing hydrogen. Air is supplied to catalytic burner 82 by line 84. Downstream from catalytic burner 82, water from water tank 30 can optionally be fed to anode gas 60 by line 86. Alternatively, methanol from methanol tank 28 can be supplied by line 88 to catalytic burner 82, so that even in the case of an insufficient anode exhaust stream 60, e.g. during start-up of the fuel-cell system, it is ensured that a sufficient amount of heat energy is generated the reformer unit 18.

Cathode exhaust stream 66 is cooled in a heat exchanger 90 of separate water circulation loop 72, and is then thermally coupled, via heat exchanger 92, to anode exhaust stream 60, before both exhaust streams 60 and 66 exit the system.

In this case, cathode exhaust stream 66 is directed through an expansion turbine 94 that is positioned, together with a compressor 96 for drawing in air 98, on a common shaft 100; the compressor being provided as an input stage, in front of two-stage compressor 50. By this means, energy contained in cathode exhaust stream 66 is recovered, in order to compress air 98 in compressor 96.

A particular advantage of this specific embodiment, which is characterized by a high efficiency, a small space requirement, and a low equipment cost, is achieved by combining two-stage compressor 50 and autothermal reformer unit 18 with the additional injection 46 of cooling water during the selective oxidation of carbon monoxide (CO) in oxidation unit 34; and by

combining this with an autonomous water circulation loop 30, 40, 42, 62, 64, 68, 70.

Claims

1. A fuel-cell system, especially a drive system of a motor vehicle, having a reformer unit (18) for producing hydrogen from a raw material, especially a liquid raw material (28), in order to operate a downstream fuel-cell unit (10); an oxidation device (34) for converting carbon monoxide into carbon dioxide being located between reformer unit (18) and fuel-cell unit (10); characterized in that a water-injection device (26) is provided at the oxidation device (34), the water-injection device injecting water into the oxidation device.

2. The fuel-cell system as recited in Claim 1, characterized in that the reformer unit (18) has a mixer (20) for the raw material (28) and an oxygen-containing substance (30), especially water and/or air.

3. The fuel-cell system as recited in Claim 1 or 2, characterized in that a two-stage compressor (49) is provided, which feeds compressed air to a process gas (38), between oxidation device (34) and fuel-cell unit (10); and/or supplies compressed air to a cathode (14) of the fuel-cell unit (10).

4. The fuel-cell system as recited in one of the preceding claims, characterized in that a water separation device (40,62,68), in particular a condenser, is provided in an exhaust-gas stream (66) from a cathode (14) of the fuel-cell unit (10), and/or in an exhaust-gas stream (60) from an anode (12) of the fuel-cell unit (10), and/or in a cleaned-gas stream (38) from the oxidation unit (34); the water separation device separating the water contained in the corresponding gas (38,60,66), and supplying it to a water-storage device (30) upstream from the autothermal reformer unit (18).

5. The fuel-cell system as recited in Claim 4, characterized in that a separate water circulation loop (72) is provided, which cools at least one of the water separation devices (40,62,68), the fuel-cell unit (10,16), the air (48) supplied to a cathode (14) of the fuel-cell unit (10), and/or the air supplied to the reformer unit (18,20).

6. The fuel-cell system as recited in one of the preceding claims, characterized in that a catalytic burner (82) is provided, which combusts exhaust gas (60) from an anode (12) of the fuel-cell unit (10), and directs the corresponding waste heat through a heat exchanger (22), to the reformer unit (18).

7. The fuel-cell system as recited in Claim 6, characterized in that the catalytic burner (82) is connected to a supply tank (28) for the raw material.

8. The fuel-cell system as recited in one of the preceding claims, characterized in that an expander (94) is provided in an exhaust-gas stream (66) of a fuel-cell-unit (10) cathode (14), and a compressor (96), particularly a two-stage compressor (50), is provided in a supply-air stream (98) of the fuel-cell unit (10); the expander and compressor being arranged on a common shaft (100).

9. The fuel-cell system as recited in one of the preceding claims, characterized in that the raw material (28) is a hydrogen-containing substance, especially methanol or gasoline.

10. A process for generating electrical energy, using a fuel-cell system, especially for a drive system of a motor vehicle; hydrogen being produced from a raw material, in a reforming process, in order to operate a

fuel-cell unit; and carbon monoxide being oxidized to carbon dioxide after the reforming process, and in front of the fuel-cell unit, characterized in that water is injected during the oxidation of carbon monoxide to carbon dioxide.

11. The process as recited in Claim 10, characterized in that the water is injected in the form of a vapor or aerosol.

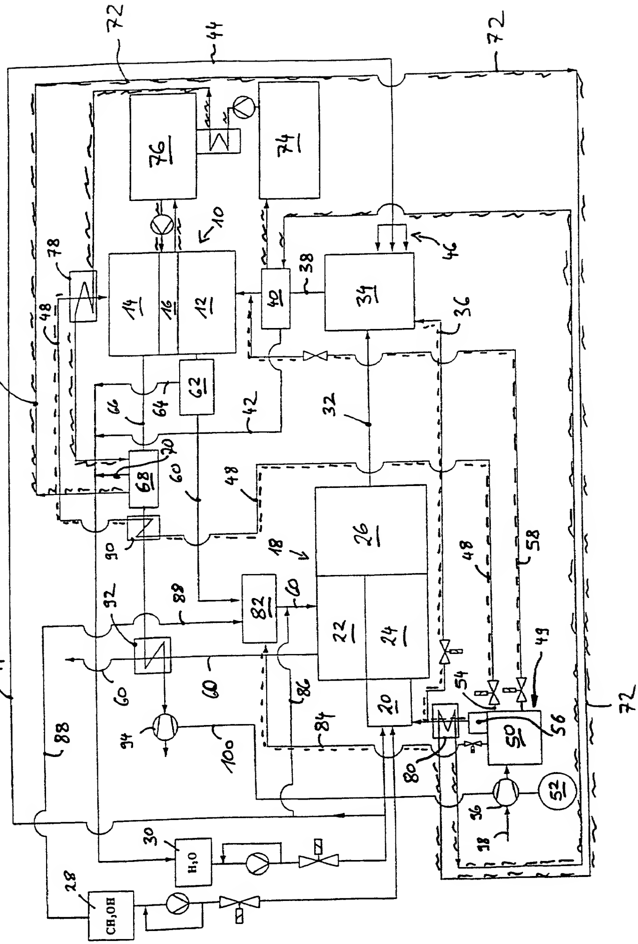
12. The process as recited in Claim 10 or 11, characterized in that compressed air is fed to a process gas, between the carbon-monoxide oxidation and the fuel-cell unit, and/or supplied to a cathode of the fuel-cell unit.

13. The process as recited in one of the Claims 10 through 12, characterized in that water is separated from a cathode-exhaust stream of the fuel-cell unit, and/or from an anode-exhaust stream of the fuel-cell unit, and is supplied to the reforming process.

14. The process as recited in one of the Claims 10 through 13, characterized in that an exhaust gas from an anode of the fuel-cell unit is burned, and the corresponding waste heat is fed to the reforming process.

15. The process as recited in one of the Claims 10 through 14, characterized in that raw material is burned, and the corresponding heat energy is fed to the reforming process.

16. The process as recited in one of the Claims 10 through 15, characterized in that a hydrogen-containing substance, especially methanol or gasoline, is used as a raw material.


H_2O
CH_3OH

COMBINED DECLARATION AND
POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **FUEL CELL SYSTEM AND METHOD FOR GENERATING ELECTRICAL ENERGY USING A FUEL CELL SYSTEM**, and the specification of which:

[ ] is attached hereto;

[ ] was filed as United States Application Serial No. _____ on _____, 19__ and was amended by the Preliminary Amendment filed on _____, 19__.

[X] was filed as PCT International Application Number PCT/EP99/03378 on the 17th day of May 1999.

[X] an English translation of which is filed herewith.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

EL244504719

PRIOR FOREIGN/PCT APPLICATION(S)
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119

Country: Federal Republic of Germany

Application No. 198 22 691.8

Date of Filing: May 20, 1998

Priority Claimed
Under 35 U.S.C. § 119: [X] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code § 120 of any United States Application or PCT International Application designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR
PCT INTERNATIONAL APPLICATIONS
DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120

U.S. APPLICATIONS

Number :

Filing Date :

PCT APPLICATIONS
DESIGNATING THE U.S.

PCT Number :

PCT Filing Date :

I hereby appoint the following attorney(s) and/or agents to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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